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PATENT

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FOR: PLASMA DISPLAY PANEL, ITS MANUFACTURING METHOD,  
AND ITS PROTECTIVE LAYER MATERIAL

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents

Washington, D.C. 20231

SIR :

I, the below named translator, hereby declare that:

1. My name and post office address are as stated below.
2. That I am knowledgeable in the English language and in the language of JP2003-055548 and JP2003-140165, and I believe the attached English translation to be a true and complete translation of JP2003-055548 and JP2003-140165.
3. The document for which the attached English translation is being submitted is a patent application on an invention entitled PLASMA DISPLAY PANEL AND ITS MANUFACTURING METHOD.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: November 1, 2006

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[Name of the Document]      Specification  
[Title of the Invention]      Plasma display panel and manufacturing  
method thereof  
[Claims]

[Claim 1] A plasma display panel in which a first and a second electrode constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, characterized in that said protective layer contains silicon carbide (SiC).

[Claim 2] A plasma display panel as defined in Claim 1, wherein the protective layer is composed of magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[Claim 3] A protective layer material of a plasma display panel in which the first and second electrodes constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, characterized in that said protective layer contains silicon carbide (SiC).

[Claim 4] A protective layer material of plasma display panel as defined in Claim 3, wherein the protective layer material is magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[Claim 5] A manufacturing method of plasma display panel in which the first and second electrodes constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, characterized in that it

comprises a film making process using a protective layer material composed of magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[Claim 6] A manufacturing method of plasma display panel as defined in Claim 5, wherein the film making process is a process using a method selected from among vacuum deposition method, spatter method and ion plating method.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a plasma display panel (hereinafter abbreviated as "PDP") used for displaying images, etc. and a manufacturing method thereof, especially to the material forming the protective layer.

[0002]

[Background Art]

Recently, of color display devices used for the display of images on computer, TV, etc., plasma display device using a plasma display panel (hereinafter referred to as "PDP") is calling much attention as color display device capable of realizing a thin and lightweight construction in large size.

[0003]

PDP makes a full-color display, by additive mixture of the so-called 3 primary colors (red, green, blue). To make this full-color display, PDP is provided with a fluorescent layer emitting the respective colors of red (R), green (G), blue (B) which are the 3 primary colors, and the phosphor constituting this fluorescent layer is excited by ultraviolet rays generated in

the discharge cell of PDP, to generate visible light in the respective colors.

[0004]

On an AC surface discharge type PDP, the electrode for main discharge is covered with a dielectric layer, and driven by memory, to lower the driving voltage. However, the driving voltage goes up as the dielectric layer deteriorates with the ion bombardment produced with a discharge. For that reason, it is necessary to form a protective layer for protecting the dielectric layer against deterioration. Generally a material with high spatter resistance such as magnesium oxide (hereinafter given as MgO), etc. for this protective layer.

[0005]

By the way, because the number of scanning lines increases as the cell structure becomes finer, it is necessary to terminate all sequences within one field = 1/60 sec, in the case of display of TV images. To meet this requirement, it is necessary to perform a high-speed drive by narrowing the pulse width of the address pulse to be applied during the writing period. However, because of existence of "delayed discharge" which is a discharge made fairly behind the rise of pulse, there were cases where the probability of termination of discharge within the applied pulse width drops, making it impossible to perform the writing in the cell to be lit, thus causing a failure of lighting.

[0006]

The main cause of a delayed discharge is believed to be the fact that primary electrons serving as trigger at the start of discharge are difficult to be discharged into the discharge space from the protective layer. In this

way, the protective layer, which faces the discharge space, relates to delayed discharge, because the driving voltage changes depending on the physical properties of the protective layer. Moreover, as protective measures against delayed discharge other than physical properties of protective layer, there is a method of either increasing the driving pulse voltage during addressing & maintenance of discharge, or shortening the distance between electrodes.

[0007]

However, increasing the driving pulse voltage is not enough for the control of delayed discharge time, because the pressure resistance and the through rate of the switching element of the drive circuit are in a relation contrary to each other, and the rise of pulse slows down. Furthermore, shortening of the distance between electrodes can be made by reducing the height of the partition, but such reduction in the height of partition causes shrinkage of the discharge space itself. As a result, the surface area of the wall enclosing the discharge space per unit volume surrounding the plasma increases, and the plasma disappears when it hits against the wall face, thus leaving a problem of drop of light emitting efficiency due to so-called wall-face loss.

[0008]

On the other hand, there is a report that, with the use of MgO containing silicon (Si) or aluminium (Al), the secondary electron discharge coefficient increases, showing excellent display characteristics (see patent literature 1, for example).

[0009]

[Patent literature 1]

[0010]

[Problems to be Solved by the Invention]

However, this technology had a defect that the grade of image display varies depending on the environmental temperature of PDP, because the electron discharge capacity is greatly affected by the temperature of the protective layer.

[0011]

The present invention, realized in consideration of such problems, aims at improving the responsiveness of generation of discharge to application of voltage and, at the same time, controlling changes of its delayed discharge time against temperature.

[0012]

[Means to Solve the Problems]

To solve the above-mentioned problems, PDP according to the present invention is characterized in that the protective layer comprises silicon carbide (SiC).

[0013]

By adopting this construction, an advantage is obtained that the protective layer forms an impurity level between the valence band and the conduction band, improving the electron discharge capacity, reducing the delayed discharge time, and eliminating flicker, to provide clear images.

[0014]

[Preferred Embodiment of the Invention]

Namely, the invention described in Claim 1 of the present invention

is a plasma display panel in which the first and second electrode constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, with a construction characterized in that said protective layer contains silicon carbide (SiC).

[0015]

Moreover, the invention described in Claim 2 of the present invention is an invention as defined in Claim 1, wherein the protective layer is composed of magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[0016]

Furthermore, the invention described in Claim 3 of the present invention is a protective layer material of a plasma display panel in which the first and second electrode constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, wherein said protective layer contains silicon carbide (SiC).

[0017]

Still more, the invention described in Claim 4 of the present invention is an invention as defined in Claim 3, wherein the protective layer material is magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[0018]

Yet more, the invention described in Claim 5 of the present invention is a manufacturing method of plasma display panel in which the first and



second electrode constituting the main pair of electrodes are covered with an insulating layer against discharge gas, and a protective layer covering said insulating layer is further formed, characterized in that it comprises a film making process using a protective layer material composed of magnesium oxide in which the range of density of silicon carbide (SiC) is 40 wt ppm ~ 15000 wt ppm.

[0019]

In addition, the invention described in Claim 6 of the present invention is an invention as defined in Claim 5, wherein the film making process is a process using a method selected from among vacuum deposition method, spatter method and ion plating method.

[0020]

A preferred embodiment of the present invention will be explained below, with reference to drawings.

[0021]

Fig. 1 is a perspective view showing, with a section, part of the image display area of AC surface discharge type PDP according to a preferred embodiment of the present invention. In Fig. 1, this AC surface discharge type PDP is constructed in a way to generate discharge in discharge space 3 by applying pulse voltage to the respective electrodes of front panel 1, and make a display by letting pass visible light in various colors generated on the back panel 2 side with the discharge through the main surface of front panel 1.

[0022]

Firstly, front panel 1 is constructed by disposing, on front glass

substrate 11, scanning electrode 12a and sustain electrode 12b, which are first electrode and second electrode constituting a pair of electrodes, in a plural number in the shape of stripes (a pair is described for the sake of convenience in Fig. 1), and forming dielectric glass layer 13, which is an insulating layer, in a way to cover the surface 11a of that pair of electrodes. Moreover, protective layer 14 composed of magnesium oxide (MgO) containing silicon carbide (SiC) is formed, in a way to cover this dielectric glass layer 13.

[0023]

Back panel 2 has address electrode 22 disposed in the shape of stripes on back glass substrate 21 in a way to be orthogonal to scanning electrode 12a and sustain electrode 12b of said front panel 1. Furthermore, electrode protective layer 23 is formed in a way to cover address electrode 22, and plays the role of protecting address electrode 22 and reflecting visible light on the front panel 1 side. On this electrode protective layer 23, partition 24 is provided upright in a way to hold address electrode 22 from both sides by extending in the same direction as address electrode 22, while phosphor layer 25 is disposed between partitions 24.

[0024]

Fig. 2 is a block diagram showing an approximate construction of an image display device constructed by connecting a drive circuit to PDP 30 indicated in Fig. 1. In Fig. 2, PDP 30 has address electrode drive unit 31 connected to address electrode 22, main scanning electrode drive unit 32 connected to scanning electrode 12a, and sustain electrode drive unit 33 connected to sustain electrode 12b, respectively.

[0025]

Moreover, Fig. 3 is a drawing for explaining the driving method of the image display device. Generally an AC surface discharge type PDP adopts a system of expressing gradation by splitting the image of one frame into a plurality of subfields (hereinafter abbreviated as SF). And, in this system, 1 SF is further divided into 4 periods, for controlling the discharge of gas in the cell. Fig. 3 is a time chart indicating the driving waveform in 1 SF.

[0026]

In this Fig. 3, electric charge on the wall uniformly accumulates in all cells in PDP, to facilitate generation of discharge during the setup period. During the address period, writing discharge of the cell to be lit is made. During the sustain period, the cell in which writing was made in the address period is lit, and that lighting is sustained. During the erase period, the lighting of the cell stops with erasure of the electric charge on the wall.

[0027]

During the setup period, a voltage higher than that of address electrode 22 and sustain electrode 12b is applied to scanning electrode 12a, to discharge the gas in the cell. The electric charge generated with this application accumulates on the wall face of the cell in a way to offset the difference of potential among address electrode 22, scanning electrode 12a, and sustain electrode 12b. As a result, negative electric charge accumulates as wall electric charge on the surface of protective layer 14 in the vicinity of scanning electrode 12a, while positive charge accumulates as wall electric charge on the surface of phosphor layer 25 in the vicinity of address electrode 22 and on the surface of protective layer 14 in the vicinity of sustain

electrode 12b. Because of this wall electric charge, a wall potential of prescribed value is produced between the scanning electrode and the address electrode, and between the scanning electrode and the sustain electrode.

[0028]

During the address period, a voltage lower than that of address electrode 22 and sustain electrode 12b is applied to scanning electrode 12a, in the case where the cell is lit. Namely, a voltage is applied, between the scanning electrode and the address electrode, in the same direction as the wall potential, and a voltage is applied also between the scanning electrode and the sustain electrode, in the same direction as the wall potential, to generate writing discharge. As a result, negative electric charge accumulates on the surface of phosphor layer 25 and on the surface of protective layer 14, while positive charge accumulates as wall electric charge on the surface of protective layer 14 in the vicinity of scanning electrode 12a. This produces a wall potential of prescribed value between the sustain electrode and the scanning electrode.

[0029]

Furthermore, the time from this application of voltage between the scanning electrode and the address electrode to the generation of writing discharge is a delay of discharge. Still more, in case no discharge took place during the address time of respective scanning electrodes 12a, a writing failure is produced and no sustain discharge is generated, and this failure appears as flickering in the display image. Yet more, with further progress of finer resolution, the address time allocated to each scanning electrode 12a becomes shorter, causing a higher probability of writing failure.

[0030]

During the sustain period, a voltage higher than that of sustain electrode 12b is applied to scanning electrode 12a. Namely, a voltage is applied, between the sustain electrode and the scanning electrode, in the same direction as the wall potential, to generate sustain discharge. As a result, it becomes possible to start lighting of the cell. And, by applying pulses in such a way that the polarity alternates between the sustain electrode and the scanning electrode, it becomes possible to emit pulses intermittently.

[0031]

During the erase period, application of erase pulses of narrow width to sustain electrode 12b generates incomplete discharge and the wall electric charge disappears, to perform erasure.

[0032]

Here, PDP according to the present invention is characterized by the material constituting the protective layer, and its density will be explained below based on a concrete example.

[0033]

In the first place, the apparatus used for vacuum deposition process for forming a protective layer made of MgO as described above is generally constituted with a preparation chamber, a heating chamber, a deposition chamber and a cooling chamber, and the substrate is conveyed in this order, to form a protective layer made of MgO. At that time, in the present invention, a MgO material with controlled SiC component used as deposition source is heated in an oxygen ambiance with a piercing type electron beam

gun as heating source, to form a desired film. Here, the amount of electron beam current, amount of partial oxygen pressure, substrate temperature, etc. during the film making may be set optionally, because they do not have any great influences on the composition of the protective layer after the film making. Following is an example of the setting.

[0034]

Degree of vacuum achieved:  $5.0 \times 10^{-4}$  Pa or under

Substrate temperature at deposition: 200°C or over

Pressure at deposition:  $3.0 \times 10^{-2}$  Pa ~  $8.0 \times 10^{-2}$  Pa

In the manufacturing method of protective layer described above, only the deposition process is described. However, other processes such as sputter process, ion plating process, etc. are also conceivable and, also in that case, similar effects can be obtained by performing component control of the target material and the raw material, and making a film from that material. In addition, a method using SiC mixed with high purity MgO, or a method using separate MgO compound and SiC compound as deposition source, target for sputtering, etc. are effective.

[0035]

Here, protective layers were prepared by using MgO deposition source with a SiC density controlled in the range of density from 0 to 22000 wt ppm as raw material of protective layer. And, the delayed discharge time of the panel forming protective layers with different SiC density was measured under the environments of -5°C to 80°C as ambient temperature of the panel. And, from the result of this measurement, the activation energy of delayed discharge time against the respective SiC density was

determined. The results of this determination are given in Fig. 4.

[0036]

Delayed discharge time as mentioned here refers to the time from the application of voltage between the scanning electrode and the address electrode to the generation of discharge, during the address period. The writing discharge was observed, with panels using a protective layer with different SiC density, and the light emission of that writing discharge for 100 times was averaged, and the time which indicated the peak of the light emission of writing discharge was determined as time of generation of discharge. Furthermore, the activation energy is a value showing changes of characteristics against temperature, and means that the lower this value the smaller the changes of characteristics against temperature (delayed discharge time in the present invention). In this Fig. 4, a case where only Si was added to MgO at 300 wt ppm is taken up, and the activation energy at that time is given as 1. In the case where only Si was added to MgO, this activation energy value was about constant regardless of its added density.

[0037]

As shown in Fig. 4, it was when the added density of Si to MgO was no less than 40 wt ppm that the activation energy value dropped compared with the conventional art in which only Si was added. However, at no less than 15000 wt ppm, the delayed discharge time increased or the voltage value necessary for the discharge became unusually high, making it impossible to display images with the conventional set voltage value. Namely, the SiC density capable of controlling the temperature characteristics of delayed discharge time, without changing the conventional

set voltage value, is believed to be 40 wt ppm to 15000 wt ppm.

[0038]

Although no clear phenomena can be grasped, this is probably because the factor which strengthened the temperature characteristics can be eliminated, with an addition to MgO of Si not only in simple form but in the form of SiC. Moreover, a SiC density of about the same value has already been confirmed, with a protective layer deposited by using the protective layer material of the SiC density mentioned above.

[0039]

From those things, with the use of protective layer obtained by impregnating MgO with SiC, added especially in the range of 40 wt ppm to 15000 wt ppm, as protective layer material, the electron discharging capacity improves with SiC, and that electron discharging capacity becomes almost unchangeable against temperature, eventually making it possible to maintain excellent panel display characteristics, regardless of the environmental temperature with PDP using the present invention.

[0040]

As described above, according to PDP of the present invention, by containing SiC in the protective layer, it becomes possible to form an impurity level between the valence band and the conduction band and improve the electron discharge capacity, thus providing advantages of reducing the delayed discharge time, and eliminating flicker, to obtain clear images. Especially, with the use of a protective layer material with a SiC density in the range of 40 wt ppm to 15000 wt ppm, the above-described protective layer can be obtained easily and accurately.



[0041]

[Advantages of the Invention]

As described above, according to PDP of the present invention, an impurity level is formed between the valence band and the conduction band and the electron discharge capacity improves, thereby providing advantages of controlling the delayed discharge time, improving the responsiveness of generation of discharge against application of voltage, and also enabling to display images with excellent temperature characteristics.

[Brief Description of the Drawings]

Fig. 1 is a perspective view showing, with a section, part of the plasma display panel according to a preferred embodiment of the present invention.

Fig. 2 is a block diagram showing an example of an image display device using the above-mentioned panel.

Fig. 3 is a drawing of signal waveform for explaining the driving method of the image display device mentioned above.

Fig. 4 is a characteristic chart for explaining advantages of the present invention.

[Description of the Reference Numerals and Signs]

1: Front panel

2: Back panel

3: Front glass substrate

12a: Scanning electrode

12b: Sustain electrode

13: Dielectric glass layer

#### **14: Protective layer**

[Name of the Document]      Abstract

[Abstract]

[Object]    The present invention aims at improving, on a plasma display panel, the responsiveness of generation of discharge, to application of voltage to control delayed discharge time, and controlling, at the same time, changes of delayed discharge time against temperature.

[Means to Solve the Problems]    Impregnating a protective layer 14 made of MgO with SiC, in the range of 40 wt ppm to 15000 wt ppm. This makes it possible to control delayed discharge time, and obtain a plasma display panel with excellent image display characteristics, regardless of the environmental temperature.

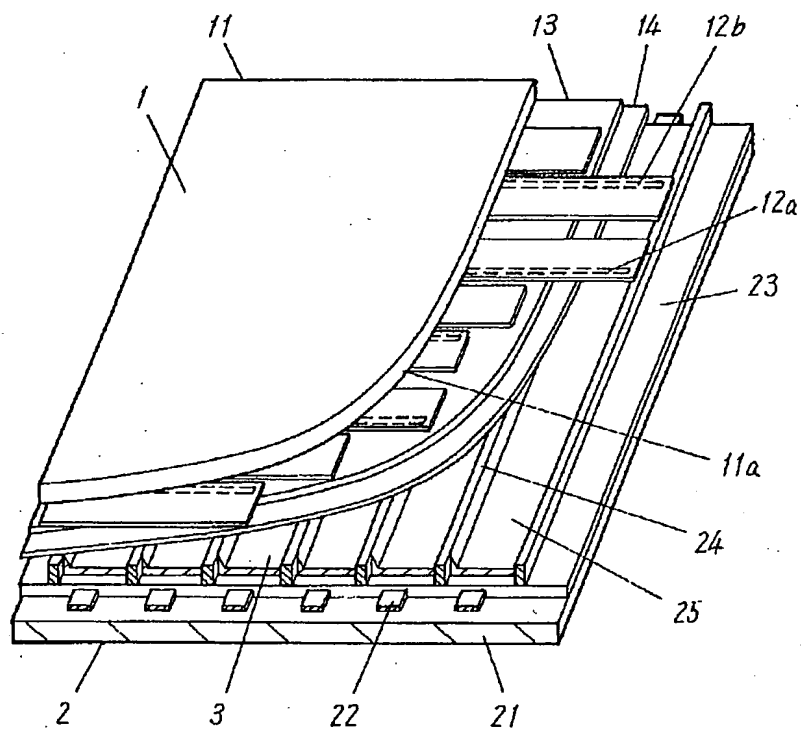
[Selected Drawing] Fig. 1

[Name of the Document]

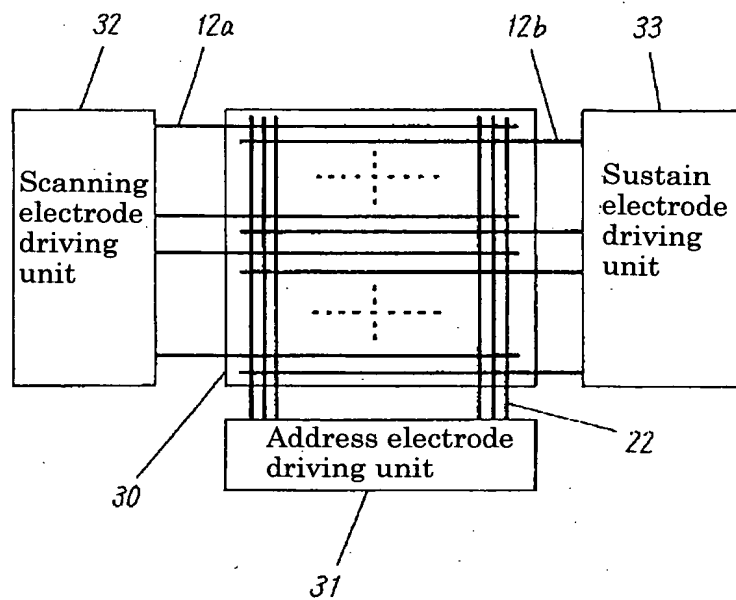
Drawing

[Fig. 1]

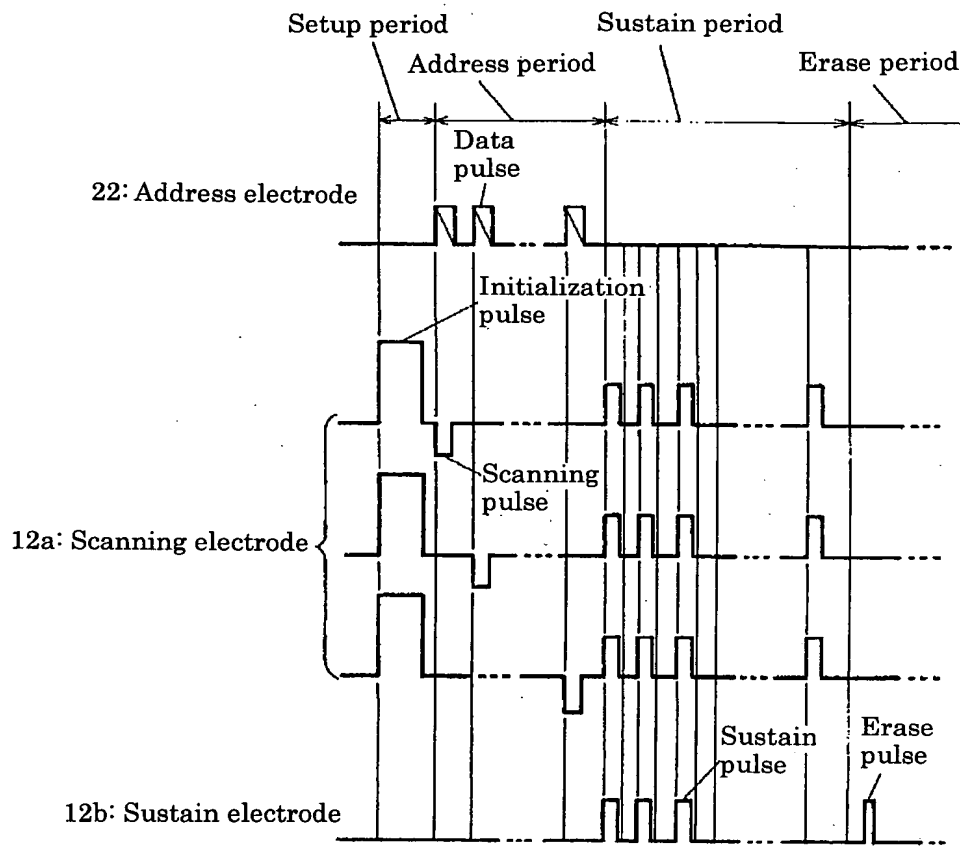
12a: Scanning electrode  
12b: Sustain electrode  
13: Dielectric glass layer  
14: Protective layer



[Fig. 2]



[Fig. 3]



[Fig. 4]

